Mississippi River Watershed Total Maximum Daily Load and Load Reduction Strategies

Stage 1 Report – Public Review Draft

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Acronyms and Abbreviations

AWQMN	Ambient Water Quality Monitoring Network
CAFO	confined animal feeding operation
CWA	Clean Water Act
HSG	hydrologic soil group
Illinois EPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geologic Survey
IPCB	Illinois Pollution Control Board
LRS	load reduction strategy
NASS	National Agricultural Statistics Survey
MOS	margin of safety
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
TMDL	total maximum daily load
U.S. EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQS	water quality standards

1. Introduction

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters that do not support their designated uses. In Illinois, load reduction strategies (LRS) are also developed to address additional pollutants in the watershed that do not have water quality standards, namely nutrients and sediment in streams. In simple terms, a TMDL or LRS is a plan to attain and maintain water quality standards or targets in waters that are not currently meeting them.

This study addresses the approximately 1,753 square mile Mississippi North Central River watershed area (portion included in Illinois only) located in northwestern Illinois. The Mississippi River in this watershed is a large river with contributing drainage area in Minnesota, Wisconsin, Iowa, and Illinois. The Mississippi River has been placed on the State of Illinois's 303(d) list, and requires development of a TMDL for atrazine. There are no LRS pollutants in this watershed, therefore no LRSs are provided.

1.1 TMDL Development Process

The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA 1991).

Illinois EPA uses a three-stage approach to develop TMDLs and LRSs for a watershed:

Stage 1 – Watershed characterization, data analysis, methodology selection, data gap identification
Stage 2 – Data collection to fill in data gaps, if necessary
Stage 3 – Model development, TMDL scenario, and implementation plan

The purpose of Stage 1 is to characterize the watershed background; verify impairments in the listed waterbody by comparing observed data with water quality standards or appropriate targets; evaluate spatial and temporal water quality variation; provide a preliminary assessment of sources contributing to impairments; and describe potential TMDL and LRS development approaches. If available water quality data collected for the watershed are deemed sufficient by Illinois EPA, Stage 2 may be omitted and Stage 3 will be completed.

The Illinois EPA will be working with stakeholders to implement the necessary controls to improve water quality in the impaired waterbody and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.2 Water Quality Impairments

The Mississippi River (IL_K-22) has been placed on the State of Illinois §303(d) list and requires development of a TMDL. This segment of the Mississippi River is listed for not supporting Public and Food Processing Water Supplies due to elevated levels of atrazine. Sources of atrazine identified in the Draft 2014 Illinois Integrated Report include: unknown sources. Atrazine is an herbicide typically applied to row crops and is widely used in the United States.

2. Watershed Characterization

The Illinois portion of the Mississippi North Central River watershed is located in northwestern Illinois and is a very small part of the overall Mississippi River watershed that encompasses portions of Minnesota, South Dakota, Wisconsin and Iowa in addition to Illinois (Figure 1). This report will focus on the watershed in Illinois (Figure 2). The western border of the watershed area stretches along the length of the Mississippi River in Illinois from New Boston to just south of Hamilton. The eastern boundary of the watershed, at the headwaters of incoming tributaries to the Mississippi, lies along the boundary of the Spoon River watershed. Covering nearly 1,754 square miles, the watershed includes land within Hancock, Henderson, Henry, Knox, Mercer and Warren Counties in Illinois. Major tributaries from the Illinois portion of the river include Pope Creek, Henderson Creek, Ellison Creek, Honey Creek, and Camp Creek.

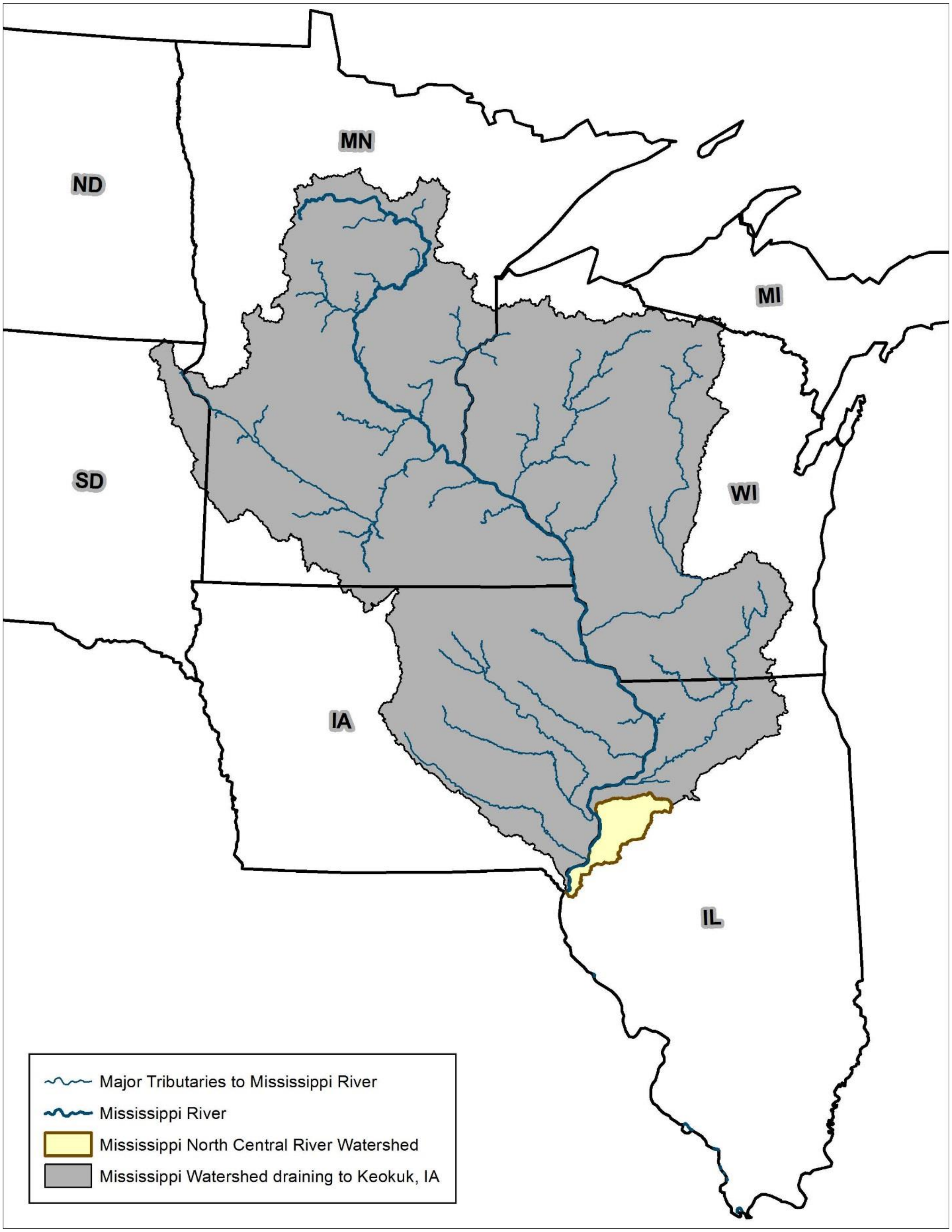

Figure 1. Mississippi River watershed draining to impaired segment

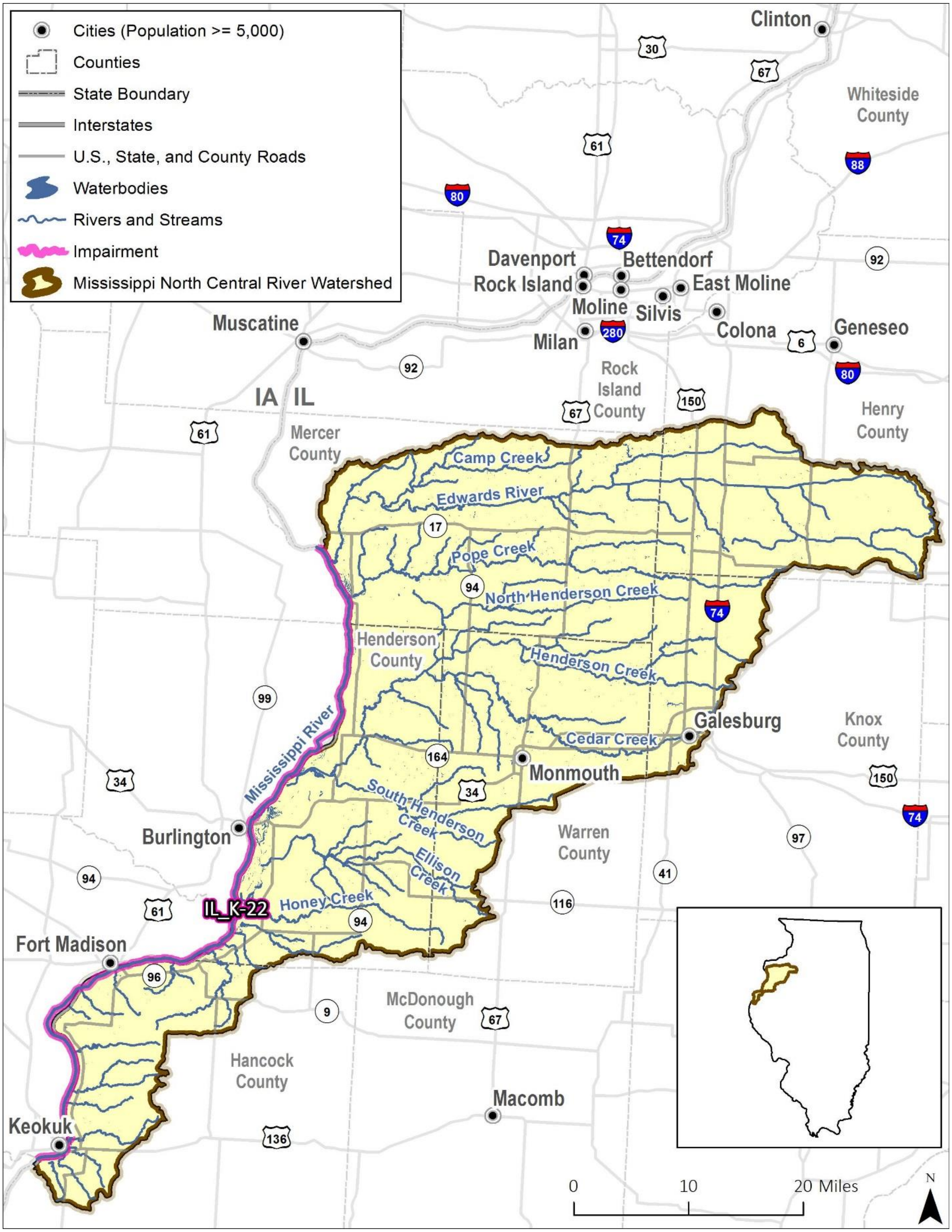

Figure 2. Mississippi North Central River watershed, TMDL project area.

2.1 Jurisdictions and Population

Counties with land located in the watershed include Hancock, Henderson, Henry, Knox, Mercer and Warren in Illinois. The approximate total population for the six counties in Illinois is nearly 164,000. Population is area weighted for the watershed in Table 1.

Table 1. Area weighted county populations within project area

County	2000	2010	Percent Change
Hancock	5,098	4,841	-5%
Henderson	7,685	6,859	-11%
Henry	16,189	16,019	-1%
Knox	10,494	9,946	-5%
Mercer	15,535	13,118	-3%
Warren	11,141	10,530	-5%
TOTAL	***64,142***	***61,313***	***-4%***

Source: U.S. Census Bureau

2.2 Climate

Climate data are available from the National Oceanic and Atmospheric Administration Global Historical Climatology Network Database; Station USC00114823 is located in La Harpe, IL in the central portion of the Mississippi North Central River watershed and was used for analysis within this report. Monthly data from 1892-2014 for precipitation, snowfall and temperature were available at the time of report development. In general, the climate of the region is continental with hot, humid summers and cold winters. Table 2 contains historical temperature data collected at the La Harpe climate station. From 1895-2014 the average high winter temperature in La Harpe was 36.2 °F and the average high summer temperature was 85.2 °F (Table 2).

Table 2. Climate summary for La Harpe (1895-2014)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High ºF	34	38	50	63	74	83	87	85	78	67	51	37
Average Low ºF	15	18	29	40	50	60	64	62	54	43	31	20
Mean Temperature ºF	24	28	39	52	62	71	76	74	66	55	41	29
Average Precipitation (in)	1.8	1.6	2.7	3.7	4.2	4.8	4.0	3.6	4.0	2.8	2.3	1.9
Average snow fall (in)	6.6	5.4	4.3	1.1	0.3	0.3	0.2	0.3	0.3	0.4	1.6	5.1

From 1895-2014, the annual average precipitation in La Harpe was approximately 37.3 inches, including approximately 24.5 inches of snowfall. In general, larger volumes of precipitation tend to occur between the months of April and September.

2.3 Land Use and Land Cover

Land use in the watershed is heavily influenced by agriculture. There is a small amount of urban area surrounding the town of Galesburg and Monmouth, and several other small towns in the watershed. Specific land use across the watershed includes agriculture (approximately 77 percent), forest (approximately 11 percent) and urban (approximately 7 percent). Corn is the primary crop in the Mississippi North Central River watershed, followed closely by soybeans. Figure 3 shows land use within the Mississippi North Central River watershed. Table 3 presents area and percent cover by land use type as provided in the 2013 Cropland Data Layer (USDA 2013).

Table 3. Watershed land use summary

Land Use / Land Cover Category	Acreage	Percentage
Corn	436,005	38.9%
Soybeans	316,303	28.2%
Deciduous Forest	124,803	11.1%
Grass/Pasture	117,946	10.5%
Developed, Open Space	35,082	3.1%
Developed, Low-Intensity	34,481	3.1%
Open Water	23,714	2.1%
Woody Wetlands	12,304	1.1%
Developed, Medium Intensity	6,619	0.6%
Alfalfa	4,758	0.4%
Herbaceous Wetlands	3,631	0.3%
Winter Wheat	2,127	0.2%
Developed High Intensity	1,898	0.2%
Evergreen Forest	836	0.1%
Other (remaining land use types)	1,588	0.1%
Total	**1,122,093**	**100.0%**

Source: 2013 Cropland Data Layer (USDA 2013)

2.4 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. The Mississippi North Central River watershed in Illinois varies in elevation from 471 to 880 feet (Figure 4). Highs occur at the headwaters of the Edwards River, near Kewanee, IL, and in the headwaters of Henderson Creek, near Wataga, IL; both on the eastern boundary of the watershed. Lows occur along the Mississippi River and adjacent floodplain; along the entire length of the eastern boundary of the watershed. The Mississippi River water elevation varies from 525 feet to 480 feet and is approximately 74 miles long in Illinois, resulting in an average stream gradient of 0.6 feet per mile.

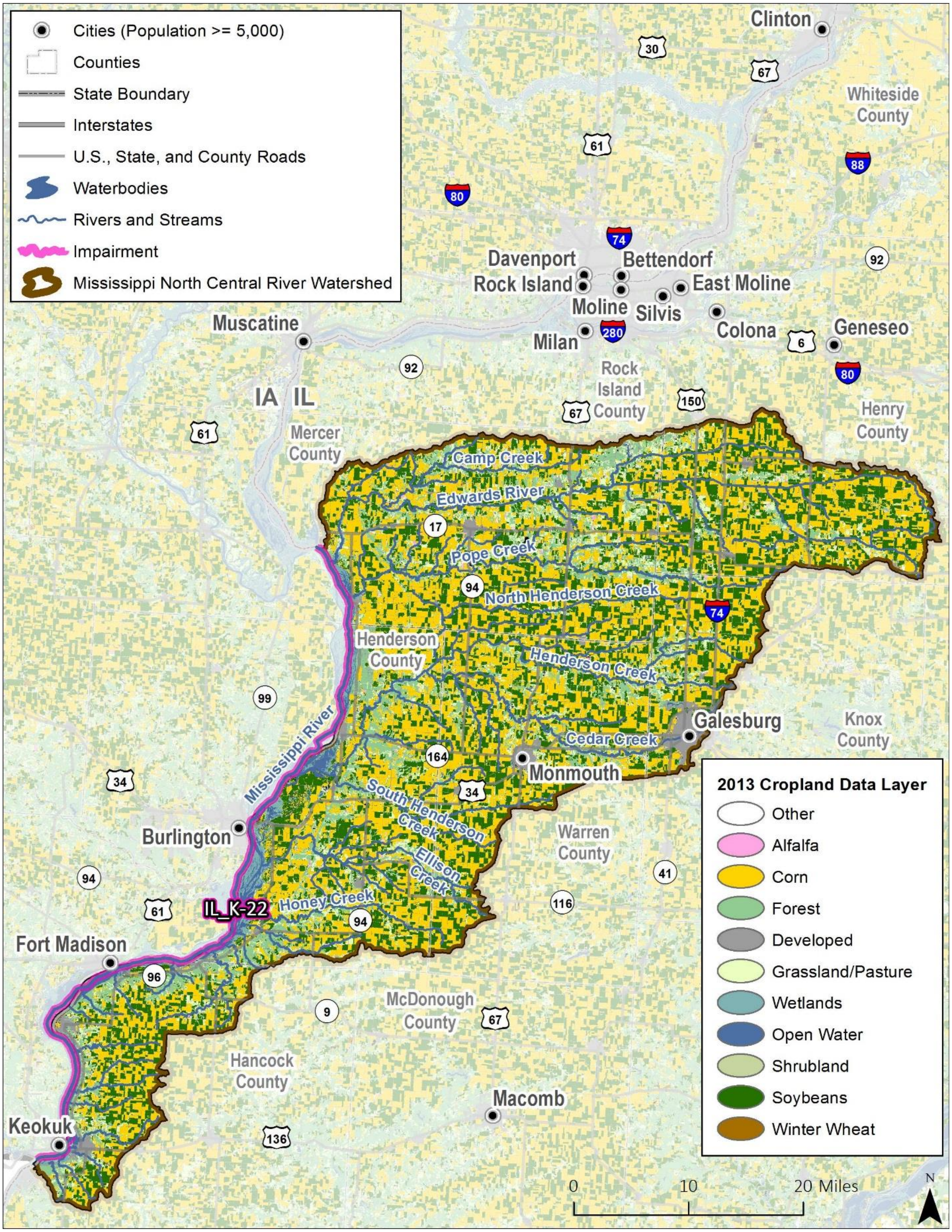

Figure 3. Mississippi North Central River watershed land use (2013 Cropland Data Layer, USDA 2013).

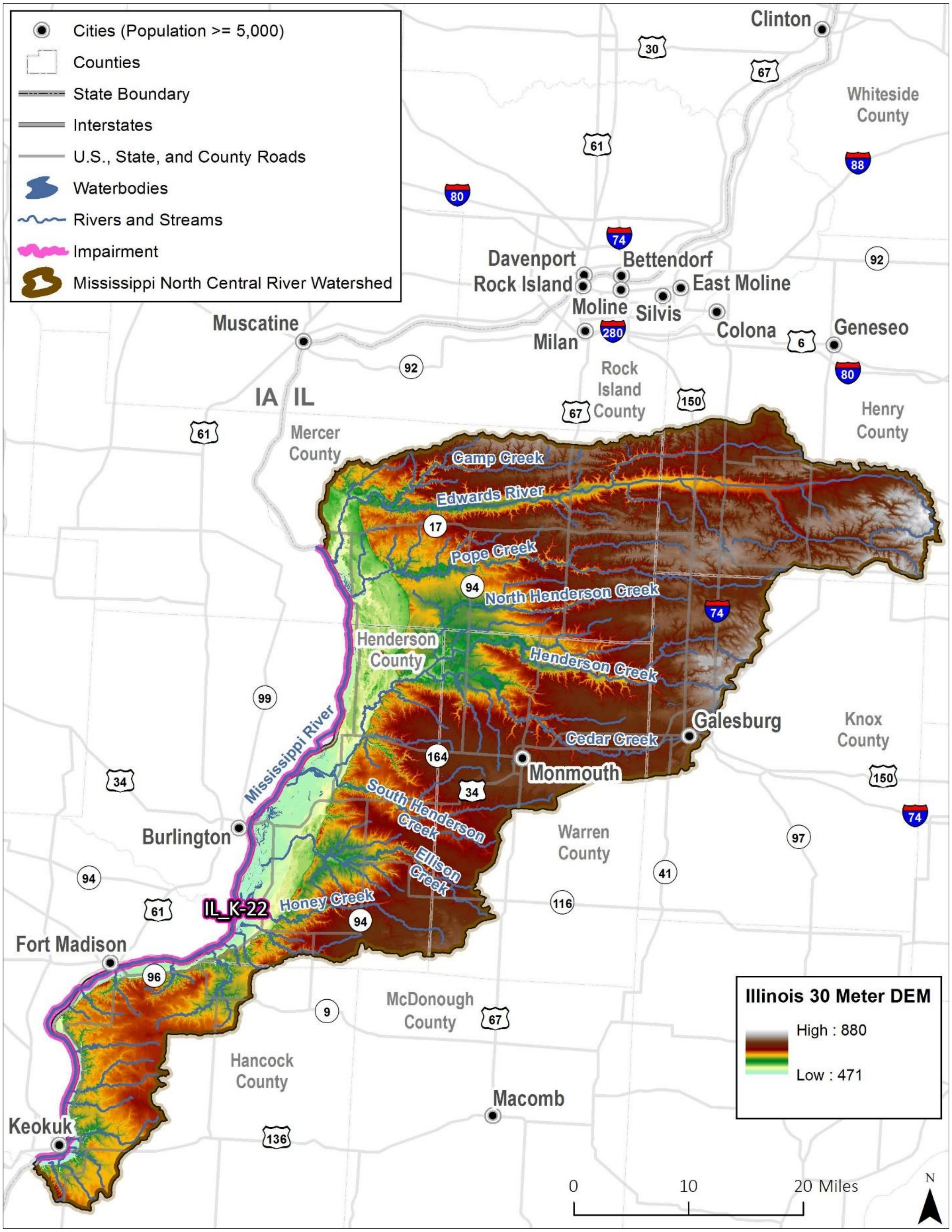

Figure 4. Mississippi North Central River watershed land elevations (Illinois 30-meter digital elevation model, ISGS 2003, elevations are in feet).

2.5 Soils

The National Cooperative Soil Survey publishes soil surveys for each county within the U.S. These soil surveys contain predictions of soil behavior for selected land uses. The surveys also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the impact of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning, the identification of special practices needed to ensure proper performance, and mapping of hydrologic soil groups (HSGs) (NRCS 2007).

HSGs refer to the grouping of soils according to their runoff potential. Soil properties that influence the HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. There are four groups of HSGs: Group A, B, C, and Group D. Table 4 describes those HSGs found in the Mississippi North Central River watershed area. The dominant soils types in the watershed include: B/D (32%), B (29%), and C/D (25%). Figure 5 further summarizes the composition of HSGs in the watershed.

Table 4. Hydrologic soil group descriptions

HSG	Group Description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A-C/D	Dual Hydrologic Soil Groups. Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

A commonly used soil attribute is the K-factor. The K-factor:

> *indicates the susceptibility of a soil to sheet and rill erosion by water. (The K-factor) is one of six factors used in the Universal Soil Loss Equation to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the Mississippi North Central River watershed range from 0.02 to 0.64, with an average value of 0.34 (Figure 6).

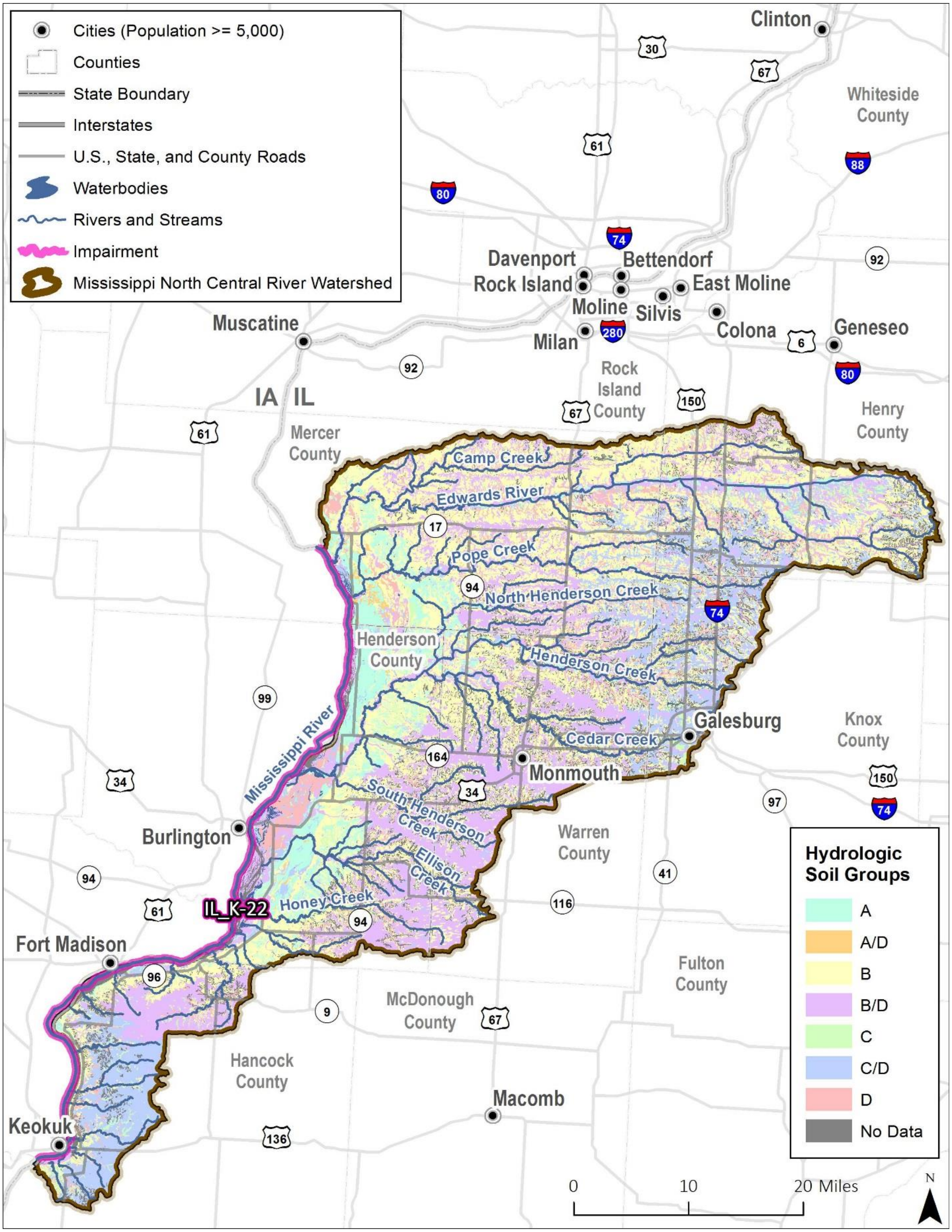

Figure 5. Mississippi North Central River watershed hydrologic soil groups (Soil Surveys for Hancock, Henderson, Henry, Knox, Mercer and Warren Counties, Illinois, NRCS SSURGO Database 2011).

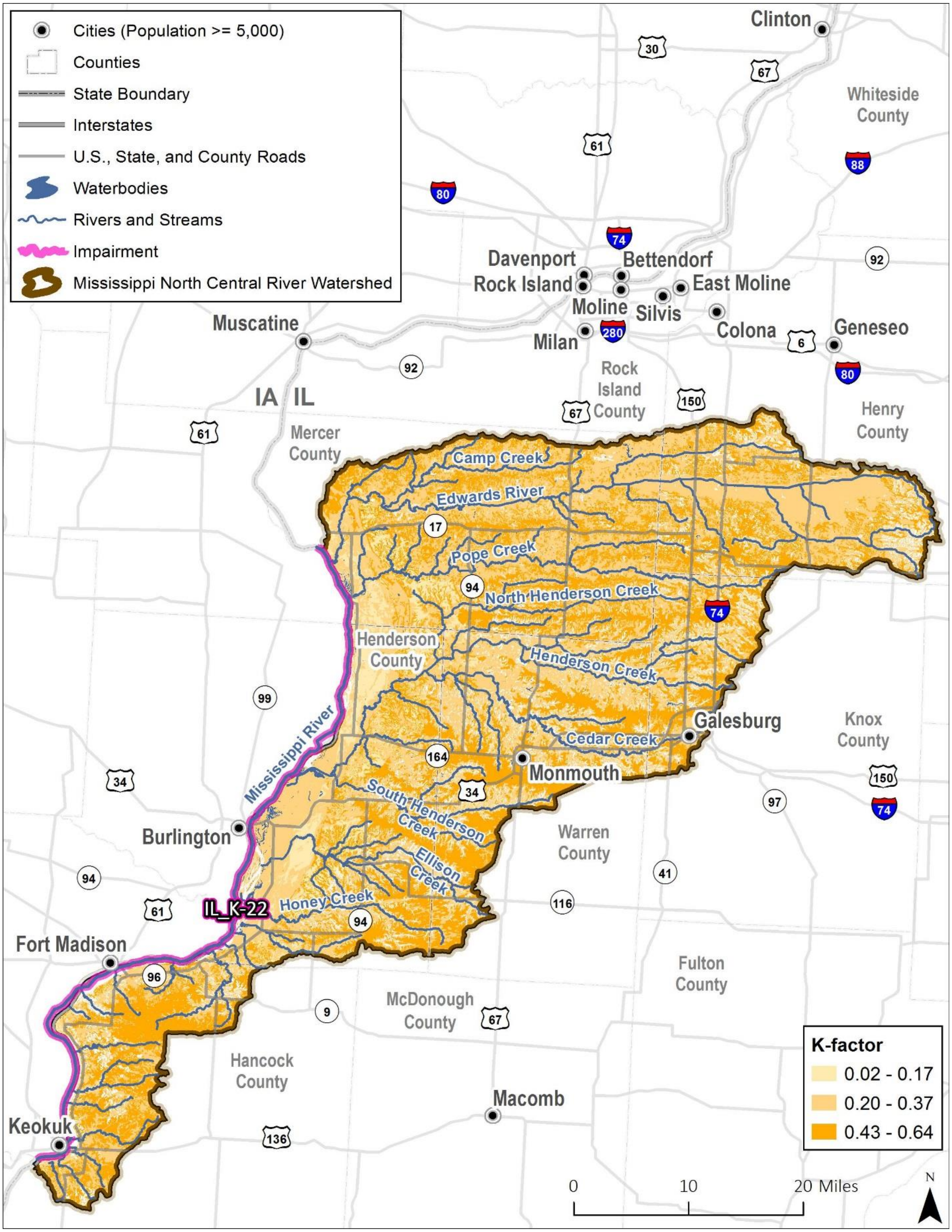

Figure 6. Mississippi North Central River watershed soil K-factor values (Soil Surveys for Hancock, Henderson, Henry, Knox, Mercer and Warren Counties, Illinois, NRCS SSURGO Database 2011).

2.6 Hydrology and Water Quality

2.6.1 USGS Flow Data

The U.S. Geological Survey (USGS) has monitored flow at several locations in the watershed (Table 5 and Figure 7). Two USGS gages are located on the mainstem of the Mississippi River at Clinton, Iowa and Keokuk, Illinois. Several other gages are located on tributaries to the Mississippi River in Illinois.

The daily average, peak history, and monthly flow data show the inherent variability associated with hydrology. Flow duration curves provide a way to address that variability and flow related water quality patterns. Duration curves describe the percentage of time during which specified flows are equaled or exceeded. Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period, based on measurements taken at uniform intervals (e.g., daily average or 15-minute instantaneous). Duration analysis results in a curve that relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently. Flow duration curves for the select USGS gages are presented in Figure 8 and Figure 9.

Table 5. USGS stream gages within watershed area

Gage ID	Watershed Area (mi.^{2})	Location	Period of Record
05420500	**85,600**	**Mississippi River at Clinton, IL[a]**	**1873-2015**
05466000	**155**	**Edwards River near Orion, IL**	**1940-2015**
05466500	**445**	**Edwards River near New Boston, IL**	**1934-2015**
05467000	**174**	**Pope Creek near Keithsburg, IL**	**1934-2015**
05467500	151	Henderson Creek near Little York, IL	1940-1958
05468500	132	Cedar Creek at Little York, IL	1940-1971
05469000	**432**	**Henderson Creek near Oquawka, IL**	**1934-2015**
05469500	83	South Henderson Creek at Biggsville, IL	1939-1971
05474500	**119,000**	**Mississippi River at Keokuk, IL**	**1878-2015**

BOLD – indicates active USGS gage
a. Nearest continuous flow record gauge upstream of watershed area on the Mississippi River

Figure 7. USGS stream gages within watershed.

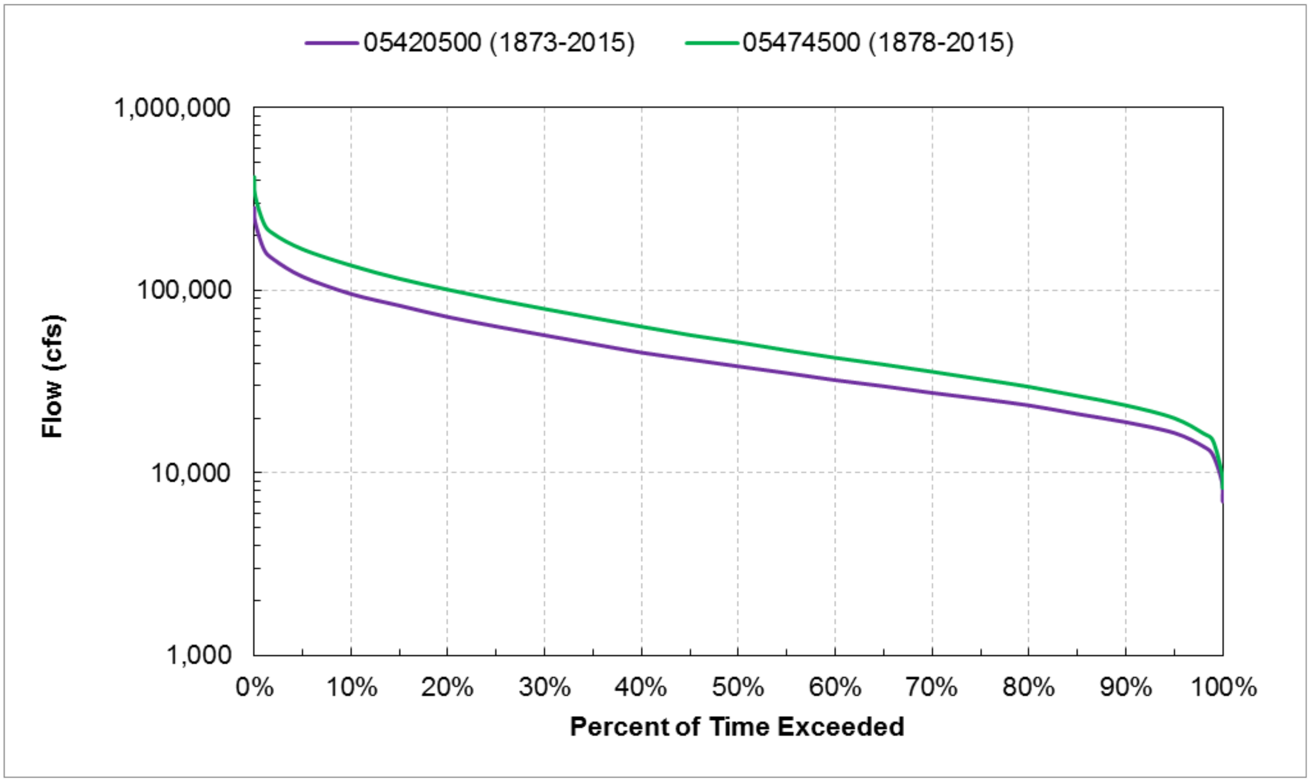

Figure 8. Flow duration curves for active USGS gages on the Mississippi River near the Mississippi North Central River watershed.

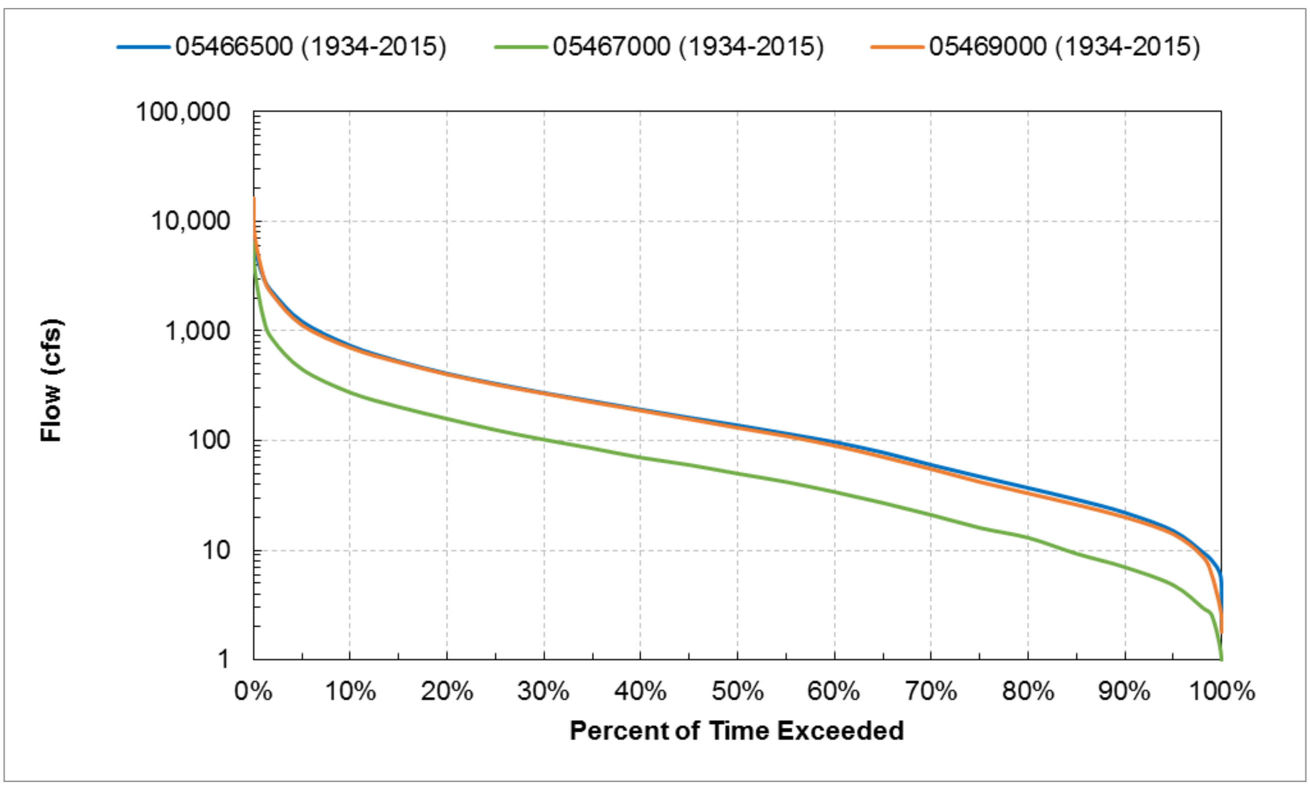

Figure 9. Flow duration curves for active USGS gages on major tributaries to the Mississippi River within the Mississippi North Central River watershed.

2.6.2 Illinois EPA Water Quality Monitoring

Routine water quality monitoring is a key part of the Illinois EPA assessment program. The goals of Illinois EPA surface water monitoring programs are to determine whether designated uses are supported, identify causes of pollution (toxics, nutrients, sedimentation) and sources (point or nonpoint) of surface water impairments, determine the overall effectiveness of pollution control programs, and identify long term resource quality trends. Illinois EPA has operated a widespread, active long-term monitoring network in Illinois since 1977, known as the Ambient Water Quality Monitoring Network (AWQMN). The AWQMN is utilized by the Illinois EPA to provide baseline water quality information, to characterize and define trends in the physical, chemical and biological conditions of the state's waters, to identify new or existing water quality problems, and to act as a triggering mechanism for special studies or other appropriate actions.

Additional uses of the data collected by the Illinois EPA through the AWQMN program include the review of existing water quality standards and establishment of water quality based effluent limits for National Pollutant Discharge Elimination System (NPDES) permits. The AWQMN is integrated with other Illinois EPA chemical and biological stream monitoring programs including Intensive River Basin Surveys, Facility –Related Stream Surveys, Fish Contaminant Monitoring, Toxicity Testing Program and Pesticide Monitoring Subnetwork which are more regionally based (specific watersheds or point source receiving stream) and cover a shorter span of time (e.g. one year) to evaluate compliance with water quality standards and determine designated use support. Information from this program is compiled by Illinois EPA into a biennial report required by the Federal Clean Water Act.

Within the Mississippi River project area, atrazine data were collected by Illinois EPA as part of the AWQMN at one station on the impaired segment and in two tributaries to the impaired segment (Figure 10 and Table 6). In addition the USGS has collected atrazine data at Clinton, Iowa, upstream of the impaired segment (Figure 7 and Table 6).

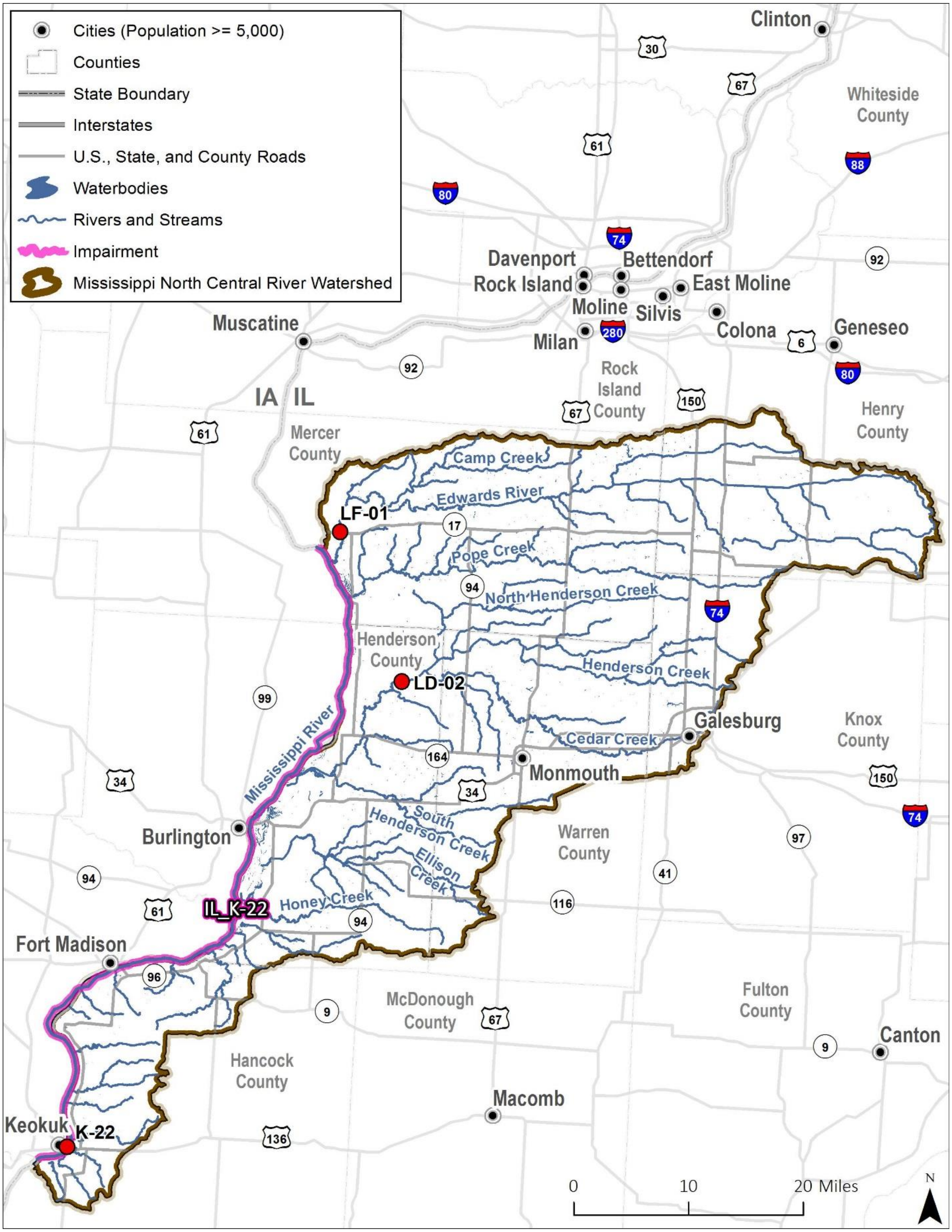

Figure 10. Illinois EPA water quality sampling sites within the watershed.

Table 6. Mississippi River watershed water quality data

AWQMN Sites	USGS Gage	Water Body	Location	Period of Record
--	05420500	Mississippi River	At Clinton, IA*	*1991-1993, 1996-2010*, 2011-2012
K-22	05474500		At Keokuk, IA	*1999-2001*, *2007-2010*, 2011-2013
Tributary sampling sites				
LF-01	--	Edwards River	RT 17 Br. 1.9 Mi. NE of New Boston	*1999, 2004*
LD-02	--	Henderson Creek	RT 94 Br. 1 Mi. S Bald Bluff	*1999, 2004*

*Data collection at Clinton, IA outside project watershed, but included here as potential reference point in determining upper watershed conditions.
Italics – samples collected outside the most recent three years of data collection used to determine impairment.

3. Watershed Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. This section provides a summary of potential sources that contribute atrazine to the Mississippi North Central River watershed.

Atrazine is an herbicide that is commonly used in the U.S. to control broadleaf weeds. In the Mississippi North Central River watershed, atrazine is applied on most corn fields. In Illinois, the use of atrazine is common, being applied on 67 percent of corn crops in 2014 for a total of 8,622,000 lbs (USDA 2015). Atrazine is typically applied in the spring or summer and can be applied pre- or post-emergent. Transport mechanisms include overland runoff, discharge from drainage tiles and contaminated dust that is delivered to the waterway through wet and dry atmospheric deposition. Atrazine is also transported easily in water, in the dissolved phase.

The 2014 impaired waters list identifies Unknown Sources as the cause of impairment.

3.1 Point Sources

Point source pollution is defined by the Federal Clean Water Act (CWA) §502(14) as:

> *"any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture."*

Point sources can include facilities such as municipal wastewater treatment plants, industrial facilities, CAFOs, or regulated storm water including municipal separate storm sewer systems. Under the CWA, all point sources are regulated under the NPDES program. Atrazine is not found in point source discharges, therefore NPDES permitted facilities are not considered a source.

3.2 Nonpoint Sources

The term nonpoint source pollution is defined as any source that does not meet the legal definition of point sources. In the case of atrazine, all sources of atrazine are assumed to be nonpoint sources, resulting from application to cropland. It is possible that atrazine can be released from manufacturing, formulation, transport and disposal. In most cases, atrazine will be broken down in the soil over one growing season following application (HHS 2003). However, the overall breakdown and transmittal of atrazine after application is dependent on a variety of factors. The half-life of atrazine in soil ranges from 60 to 150 days, depending on the total oxygen and water content within soils. Soils with no oxygen (anaerobic) or varying oxygen with depth can greatly influence the breakdown of atrazine with a potential half-life increase to several years. Further, atrazine readily dissolves in water and weakly bonds to soil particles resulting in transmittal in environments with high runoff potential or persistence and transport to groundwater within soils with high water content (USDA 1994). Atrazine in water degrades much slower.

The Mississippi North Central River watershed is 68 percent cultivated crops; 40 percent in corn and 28 percent in soybeans in 2013 based on the Cropland Data Layer (USDA 2013). Atrazine application on these cultivated areas contributes loading by runoff and through infiltration into shallow groundwater or drain tiles. Therefore, the location and quantity of atrazine applied to the landscape can greatly affect the resulting concentrations within nearby waterbodies.

The USGS, as part of the Pesticide National Synthesis Project established in 1992, has developed county-level application estimates nationally for a large variety of pesticides. Annual agricultural pesticide use is estimated through a combination of pesticide use data collected during proprietary surveys of farm operations within crop reporting districts and annual harvested-crop acreages reported by the U.S. Department of Agriculture National Agricultural Statistics Service (NASS). County-level application estimates are available from the USGS in map and tabular form for 1992-2014 (NAWQA 2014). Atrazine application estimates for counties within the Mississippi North Central River watershed are presented within Table 7 and Figure 11.

Table 7. Total atrazine application by county, Mississippi River K-22 (NAWQA 2014)

County	Year	Total Application (tons/yr)	Average (2008-2014) (tons/yr)
Hancock	2008	71	83
	2009	85	
	2010	92	
	2011	78	
	2012	82	
	2013*	90	
	2014*	84	
Henderson	2008	40	47
	2009	50	
	2010	53	
	2011	47	
	2012	43	
	2013*	50	
	2014*	47	
Henry	2008	73	91
	2009	73	
	2010	106	
	2011	103	
	2012	113	
	2013*	87	
	2014*	80	
Knox	2008	74	83
	2009	85	
	2010	95	
	2011	80	
	2012	83	
	2013*	85	
	2014*	76	
Mercer	2008	44	52
	2009	45	
	2010	60	
	2011	61	
	2012	52	
	2013*	52	
	2014*	48	
Warren	2008	72	82
	2009	83	
	2010	90	
	2011	78	
	2012	97	
	2013*	82	
	2014*	74	

*Preliminary estimates

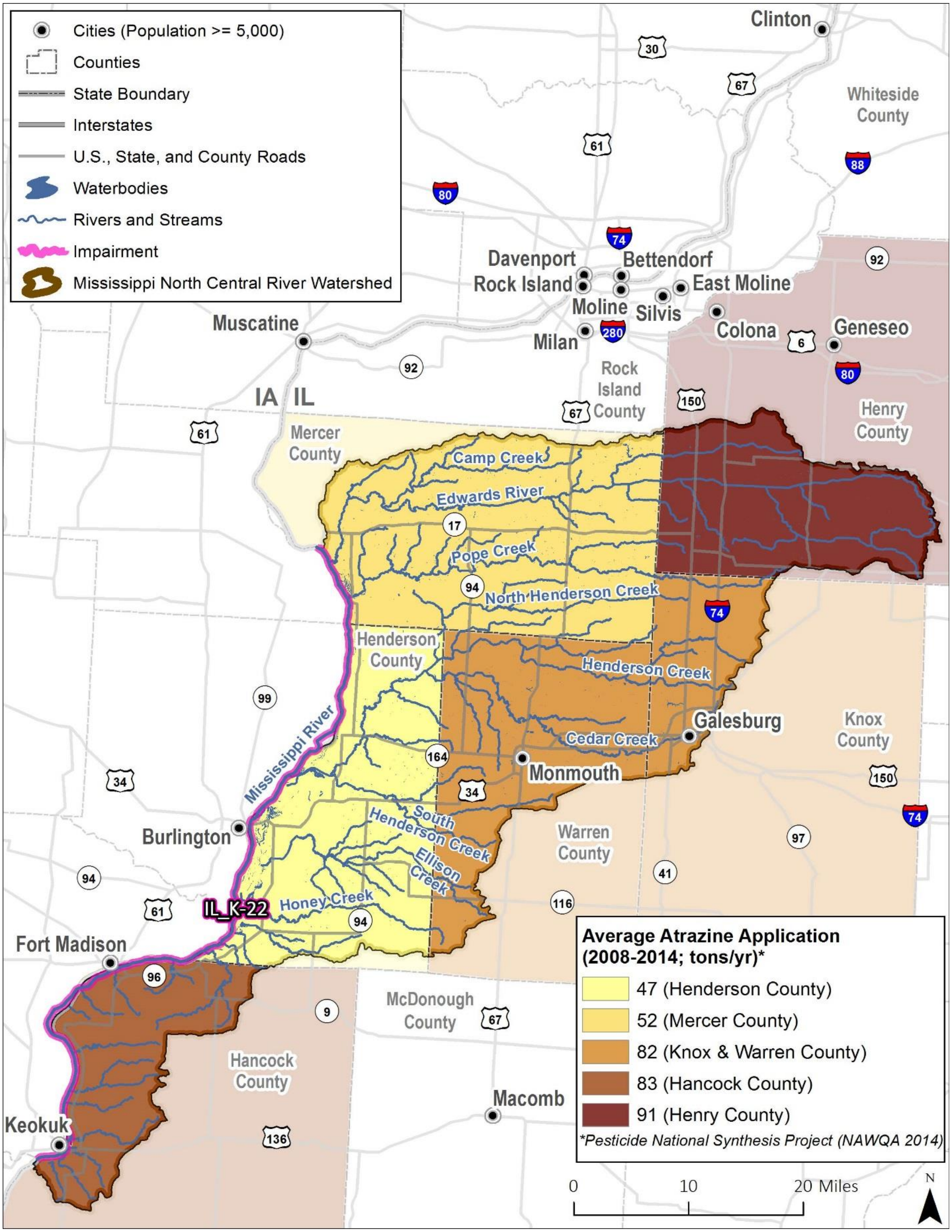

Figure 11. Average atrazine application by county, Mississippi River K-22.

4. TMDL Endpoint

This section presents information on the water quality impairment within the Mississippi North Central River watershed and the associated water quality standards (WQS).

4.1 Applicable Standards

WQS are designed to protect beneficial uses. The authority to designate beneficial uses and adopt WQS is granted through Title 35 of the Illinois Administrative Code. Designated uses to be protected in surface waters of the state are defined under Section 303, and applicable WQS are designated under Section 302 (Water Quality Standards) and Section 611 (Primary Drinking Water Quality Standards). Designated uses and WQS are discussed below.

4.1.1 Designated Uses

Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB) to assess the designated use support for Illinois waterbodies. The following are the use support designations provided by the IPCB that apply to water bodies in the Mississippi North Central River watershed:

General Use Standards – These standards protect for:

- Aquatic life
- Wildlife
- Agricultural uses
- Primary contact where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing
- Secondary contact that is any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity
- Most industrial uses

These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

Public and food processing water supply standards – These standards are cumulative with the general use standards and apply to waters of the state at any point at which water is withdrawn for treatment and distribution as a potable supply to the public or for food processing.

4.1.2 Assessment Guidelines

Attainment of public and food processing water supply use is assessed only in waters in which the use is currently occurring, as evidenced by the presence of an active public-water supply intake. The assessment of public and food processing water supply use is based on conditions in both untreated and treated water. By incorporating data through programs related to both the federal Clean Water Act and the federal Safe Drinking Water Act, Illinois EPA believes that these guidelines provide a comprehensive assessment of public and food processing water supply use. Assessments of public and food processing water supply use recognize that characteristics and concentrations of substances in Illinois surface waters can vary and that a single assessment guideline may not protect sufficiently in all situations. Using multiple assessment guidelines helps improve the reliability of these assessments. When applying these assessment guidelines, Illinois EPA also considers the water-quality substance, the level of treatment available for that substance, and the monitoring frequency of that substance in the untreated water. Table 8 includes the assessment guidelines for waters with public and food processing water supply designated uses.

Table 8. Guidelines for assessing public water supply in waters of the State (IEPA 2014)

Degree of Use Support	Guidelines
Fully Supporting (Good)	For each substance in untreated water[a], for the most-recent three years of readily available data or equivalent dataset, a) < 10% of observations exceed an applicable Public and Food Processing Water Supply Standard[b]; and b) for which the concentration is not readily reducible by conventional treatment, i) no observation exceeds by at least fourfold the <u>treated</u>-water Maximum Contaminant Level threshold concentration[c] for that substance; and ii) no quarterly average concentration exceeds the <u>treated</u>-water Maximum Contaminant Level threshold concentration[c] for that substance; and iii) no running annual average concentration exceeds the <u>treated</u>-water Maximum Contaminant Level threshold concentration[d] for that substance; and[d] For each substance in treated water, no violation of an applicable Maximum Contaminant Level[c] occurs during the most recent three years of readily available data.
Not Supporting (Fair)	For any single substance in untreated water[a], for the most-recent three years of readily available data or equivalent dataset, a) > 10% of observations exceed a Public and Food Processing Water Supply Standard[b];or b) for which the concentration is not readily reducible by conventional treatment, i) at least one observation exceeds by at least fourfold the <u>treated</u>-water Maximum Contaminant Level threshold concentration[c] for that substance; or ii) the quarterly average concentration exceeds the <u>treated</u>-water Maximum Contaminant Level threshold concentration[c] for that substance; or iii) the running annual average concentration exceeds the <u>treated</u>-water Maximum Contaminant Level threshold concentration[c] for that substance. or, For any single substance in treated water, at least one violation of an applicable Maximum Contaminant Level[3] occurs during the most recent three years of readily available data.
Not Supporting (Poor)	Closure to use as a drinking-water resource (cannot be treated to allow for use).

a. Includes only the untreated-water results that were available in the primary computer database at the time data were compiled for these assessments
b. 35 I11. Adm. Code 302.304, 302.306 (http://www.ipcb.state.il.us/SLR/IPCBandIEPAEnvironmentalRegulations-Title35.aspx)
c. 35 I11. Adm. Code 611.300, 611.301, 611.310, 611.311, 611.325.
d. Some waters were assessed as Fully Supporting based on treated-water data only.

One of the assessment guidelines for untreated water relies on a frequency-of-exceedance threshold (10 percent) because this threshold represents the true risk of impairment better than does a single exceedance of a water quality criterion. Assessment guidelines also recognize situations in which water treatment that consists only of "*...coagulation, sedimentation, filtration, storage and chlorination, or other equivalent treatment processes*" (35 Ill. Adm. Code 302.303; hereafter called "conventional treatment") may be insufficient for reducing potentially harmful levels of some substances. To determine if a Maximum Contaminant Level (MCL) violation in treated water would likely occur if treatment additional to conventional treatment were not applied (see 35 Ill. Adm. Code 302.305), the concentration of the potentially harmful substance in untreated water is examined and compared to the MCL threshold concentration. If the concentration in untreated water exceeds an MCL-related threshold concentration, then an MCL violation could reasonably be expected in the absence of additional treatment.

Compliance with an MCL for treated water is based on a running 4-quarter (i.e., annual) average, calculated quarterly, of samples collected at least once per quarter (Jan.-Mar., Apr.-Jun., Jul.-Sep., and Oct.-Dec.). However, for some untreated-water intake locations sampling occurs less frequently than once per quarter; therefore, statistics comparable to quarterly averages or running 4-quarter averages cannot be determined for untreated water. Rather, for substances not known to vary regularly in concentration in Illinois surface waters (untreated) throughout the year, a simple arithmetic average concentration of all available results is used to compare to the MCL threshold. For substances known to vary regularly in concentration in surface waters during a typical year (e.g., atrazine), average concentrations within the relevant sub-annual (e.g., quarterly) periods are used.

4.1.3 TMDL Endpoint

Environmental regulations for the State of Illinois are contained within the Illinois Administrative Code, Title 35. Specifically, Title 35, Part 611, Subpart F contains MCLs for various contaminants. The TMDL endpoint for atrazine will be the MCL from drinking water protection, 3.0 µg/L.

5. Data Analysis

An important step in the TMDL development process is the review of water quality conditions, particularly data and information used to list segments. This section provides a brief review of available water quality information. All relevant available data are presented below; however data that are greater than 3 years old are not used when evaluating impairment status. Each data point was reviewed to ensure the use of quality data in the analysis below.

Table 9 and Figure 12 provide a summary of atrazine data for monitoring site K-22 at the downstream end of the impaired segment. There are minimal quarterly data available at K-22 and the average of collected data is below the 3 µg/L drinking water protection MCL. However, one sample and quarterly average value during the assessment period (2008-2010) and one sample and quarterly average during the last three years of data collection (2011-2013), are above the MCL confirming the impairment. Monitoring stations along tributaries to the impaired segment show a similar trend with the average below the MCL, although one exceedance is observed within historic data at LF-01 along Edwards River (Table 10).

Table 9. Atrazine data summary, Mississippi River K-22

Sample Site	Date	Result (µg/L)	Quarterly Average (µg/L)
Atrazine			
	1/18/2007	*0.13*	*0.13*
	3/19/2007	*0.13*	
	5/9/2007	*1.5*	*1.5*
	8/14/2007	*0.13*	*0.27*
	9/24/2007	*0.4*	
	5/7/2008	*0.061*	*0.061*
	7/9/2008	*0.77*	*0.36*
	8/25/2008	*0.16*	
	9/24/2008	*0.14*	
	11/13/2008	*0.16*	*0.16*
	5/28/2009	*6.4*	*6.4*
	7/22/2009	*0.18*	*0.12*
	8/27/2009	*0.067*	
K-22	*2/24/2010*	*0.049*	*0.049*
	11/15/2010	0.02	0.0195
	3/23/2011	0.061	0.061
	5/19/2011	1.9	1.9
	9/15/2011	0.044	0.044
	12/1/2011	0.06	0.06
	3/7/2012	0.04	0.04
	5/29/2012	0.16	0.16
	9/25/2012	0.057	0.057
	12/4/2012	0.02	0.0195
	3/14/2013	0.044	0.044
	5/28/2013	8.3	8.3
	9/18/2013	0.078	0.078
	12/10/2013	0.096	0.096

Italics - samples collected outside the most recent three years of data collection used to determine impairment.
Red values indicate samples above the MCL

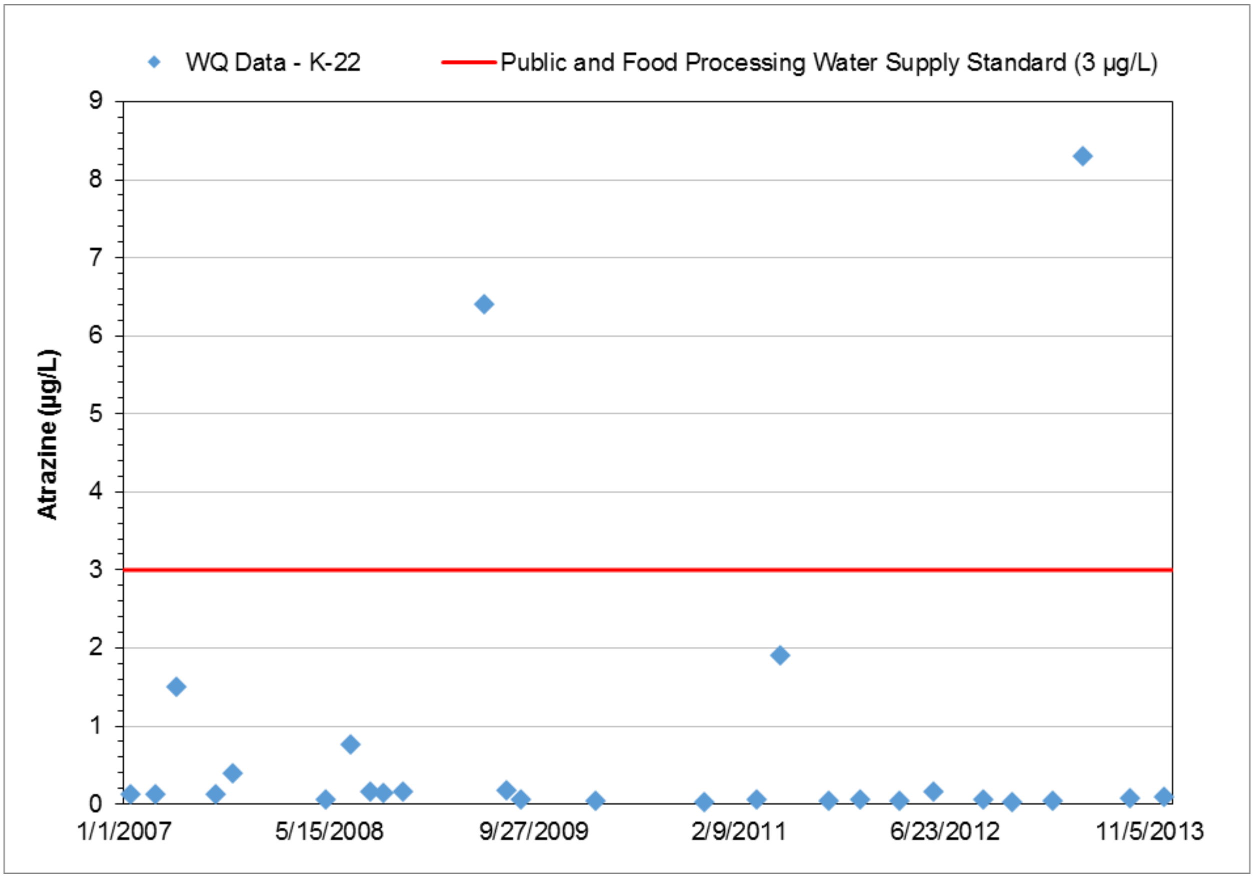

Figure 12. Atrazine water quality time series, Mississippi River K-22

Table 10. Historic atrazine data summary, Illinois tributaries to Mississippi River K-22

Sample Site	Date	Result (µg/L)	Quarterly Average (µg/L)
Atrazine			
LF-01 (Edwards River)	*4/27/1999*	*1.3*	*6.2*
	6/8/1999	*11*	
	7/13/1999	*0.58*	*0.45*
	9/1/1999	*0.31*	
	4/7/2004	*0.017*	*0.20*
	6/30/2004	*0.38*	
	8/23/2004	*0.15*	*0.15*
LD-02 (Henderson Creek)	*4/27/1999*	*0.41*	*1.5*
	6/8/1999	*2.6*	
	9/1/1999	*0.27*	*0.27*
	4/7/2004	*0.017*	*0.073*
	6/30/2004	*0.13*	
	8/23/2004	*0.017*	*0.017*

Italics - samples collected outside the most recent three years of data collection used to determine impairment.
Red values indicate samples above the MCL

6. TMDL Methods and Data Needs

The first stage of this project has been an assessment of available data, followed by evaluation of their credibility. The types of data available, their quantity and quality, and their spatial and temporal coverage relative to impaired segments or watersheds drive the approaches used for TMDL model selection and analysis. Credible data are those that meet specified levels of data quality, with acceptance criteria defined by measurement quality objectives, specifically their precision, accuracy, bias, representativeness, completeness, and reliability. The following sections describe the method that will be used to derive a TMDL and the additional data needed to develop credible TMDL. A duration curve approach is suggested to evaluate the relationships between hydrology and water quality and calculate the TMDL.

6.1.1 Load Duration Curve Approach

The primary benefit of duration curves in TMDL development is to provide insight regarding patterns associated with hydrology and water quality concerns. The duration curve approach is particularly applicable because water quality is often a function of stream flow. For instance, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. Other parameters, such as chloride, may be more concentrated at low flows and more diluted by increased water volumes at higher flows. The use of duration curves in water quality assessment creates a framework that enables data to be characterized by flow conditions. The method provides a visual display of the relationship between stream flow and water quality.

Allowable pollutant loads have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value (in cubic feet per second) by the water quality standard/target for a contaminant (µg/L), then multiplying by conversion factors to yield results in the proper unit (i.e., pounds per day or count/day). The resulting points are plotted to create a load duration curve.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or load duration curve.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the river. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low flow conditions, and may be derived from sources such as illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. Using the load duration curve approach allows Illinois EPA to determine which implementation practices are most effective for reducing loads on the basis of flow regime. If loads are considerable during wet-weather events (including snowmelt), implementation efforts can target those best management practices that will most effectively reduce stormwater runoff.

The stream flows displayed on load duration curves may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five hydrologic zones (U.S. EPA 2007):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the CWA and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics.

6.1.2 Data Needs

No additional data are needed to develop the TMDL.

7. Public Participation

<to be included following Stage 1 meeting>

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